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ABSTRACT

Five groups of college students, each of which had undergone a different high school biology experience, were tested with the Biological Sciences Curriculum Study (BSCS) Comprehensive Final Examination to obtain data on the lasting effects of the BSCS biology courses. The analysis of variance approach indicated highly significant differences among the five groups. However, examination of the five means shows that the differences are not great enough to have clear educational meaning. The predicted scores raise questions about the effectiveness of either the BSCS courses, the BSCS examination, or both. (Author)

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BSCS Biology--Its Lasting Effects

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Introduction

The paucity of curriculum studies which evaluate the long-term effects of science courses has long been bemoaned by science educators. During the 1960-70 decade, the combination of experimental federally-supported secondary school science curricula and college entrance populations, constituting a large percentage of recent high school graduates, offered an opportunity to make an analysis of long term effects. The present study is an effort to use this opportunity for longitudinal data collection to examine the question: Is there a difference in Biological Sciences Curriculum Study (BSCS) biological knowledge between students who have taken BSCS biology courses and those who have taken a traditional biology course when a retention test is given two or three years after they complete the course? Further, is there any appreciable difference in BSCS biological knowledge between students who have had "no" biology and those who have had biology--either BSCS or traditional?

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Several previous studies had compared immediate course-end outcomes of BSCS versions with those of traditional courses. One of the most detailed was carried out by the BSCS itself and reported by Wallace.[1]

[1] Wallace, Wimburn L. "The BSCS 1961-62 Evaluation Program--a Statistical Report." BSCS Newsletter, September 1963, 22-24.

It was found that BSCS groups outperformed the traditional control groups by three points on the BSCS Comprehensive Final Examination. Lisonbee and Fullerton[2] compared low, middle, and high ability

[2] Lisonbee, Lorenzo, and Fullerton, Bill J. "The Comparative Effect of BSCS and Traditional Biology on Student Achievement." School Science and Mathematics, 64: 4-12; 1964.

subgroups from traditional and BSCS courses and found statistically significant differences only for the middle ability groups on the BSCS Comprehensive Final. Using two tests that were non-BSCS in their objectives, Lance[3] compared students using the Green Version

[3] Lance, Mary Louise. "A Comparison of Gains in Achievement Made by Students of BSCS High School Biology and Students of a Conventional Course in Biology." Dissertation Abstracts, 25: 2814; 1964.

of the BSCS course with students in a traditional course. No significant difference was found between achievement gains of the BSCS and the traditional groups. In a similar study, Lewis[4]

[4] Lewis, William A. "An Evaluation of Four Selected Approaches to Teaching High School Biology." Dissertation Abstracts, 27: 1689-A; 1966.

also found no significant difference between the BSCS and the traditional groups. Findings for these studies, however, were based on an end-of-the-course examination.

Procedures

In January of 1968 the BSCS Comprehensive Final Examination, Forms J and K, was given to 972 Michigan State University students who were about to start the second term of a three-term sequence in a required general education science course. The first term of their science course covered physical science topics only. Most students were freshmen who had taken a high school biology course in the 9th or 10th grade in the 1963-64 or 1964-65 school years. Some had taken biology as high school upperclassmen. The great majority of these students were non-science majors.

Before being tested, the students were asked to indicate whether they had taken a BSCS course, another type of biology course, or no biology course at all. Their memories were stimulated by projecting a colored slide of the three BSCS textbooks. Because conflicting, incomplete, or unclassifiable information was supplied by some of the 972 students tested, only 747 usable test scores were obtained. The test results for these 747 students

were analyzed and the performance of the separate groups--based on their high school biology experience--were compared.

Results - Test Analysis

Since two "comparable" forms, J and K, of the BSCS Comprehensive Final Examination were used, student performance on each form was analyzed to see if the forms yielded comparable scores. If there were widespread differences in performance on the two forms, separate analysis (one for students who took Form J and a second for students who took Form K) would be necessary.

Table I shows the test statistics for the two forms of the examination.

TABLE I

Test Statistics on Forms J and K of the BSCS Comprehensive Final Examination

Type of Data	Form J	Form K
Number Taking	386	361
Range	5-41	12-39
Mean	24.1	24.0
SD	5.15	4.88
Average Item Difficulty	52	52
Average Item Discrimination	24	24
Kuder Richardson Formula 20 Reliability Coefficient	.60	.60
Standard Error of Measurement	3.26	3.12

As indicated above, 386 students took Form J and 361, Form K. Student scores ranged from 5 to 41 on Form J and from 12 to 39 on Form K. The standard deviations reflected these differences and were 5.2 and 4.9 respectively.

The average item difficulty--the percentage of the total group marking a wrong answer--was the same (52) for each form. The average item discrimination reflecting the difference between the percentage of the "upper" group marking the right answer and the percentage of the "lower" group marking the right answer, was the same for each form but was atypically low for a standardized test of this kind. The Kuder Richardson Formula 20 reliability was .60 for each form and reflects an unusually low degree of internal consistency in the examination as used in this study. Finally, the standard error of measurement reflecting the amount of error in an individual's test score was 3.26 for Form J and 3.12 for Form K. Since the test data indicated that the forms were operating almost identically, it was decided to combine their results.

However, to explore the low internal consistency, the Kuder Richardson Formula 20 reliability was calculated for each high school biology experience group for Form J. Table II reports these findings.

TABLE II

Kuder Richardson Formula 20 Reliability Coefficients Calculated on Five Groups Taking Form J of the BSCS Comprehensive Final Examination

	Group	N	r
I	BSCS Green	21	.66
II	BSCS Blue	46	.71
III	BSCS Yellow	62	.69
IV	Other H.S. Biology	237	.52
V	No H.S. Biology	20	.10

The reliability coefficients for these sub-groups support the .60 reliability index reported earlier. Slightly higher reliabilities were obtained for the BSCS sub-groups.

Results - Group Performance

Five groups of students were identified. Three groups had taken courses built around the three BSCS versions (Green, Blue, and Yellow). The fourth group consisted of students who had biology courses other than a BSCS version, and the fifth group was composed of students who indicated that they had no biology in High school. Table III shows the number, mean score, and standard deviation for the five groups.

TABLE III

Mean Scores and Standard Deviation on the BSCS Comprehensive for Five High School Biology Groups

	Group	N	Mean	SD
I	BSCS Green	40	24.0	5.5
II	BSCS Blue	80	26.5	5.5
III	BSCS Yellow	106	24.9	5.5
IV	Other H.S. Biology	485	23.7	4.7
V	No H.S. Biology	36	21.4	4.1
	Total	747		

As indicated, test data was complete on 747 students; 226 of these students had some form of BSCS program. Another 485 had "other" biology in high school and 36 had "no" high school biology. The average scores made on the examination ranged from 21.4 for the "no" biology group to 26.5 for the students who experienced the Blue BSCS version.

To obtain an index of the relationship between group membership and test scores a regression equation according to the method of Bottenberg and Ward[5] was constructed. Score made on the BSCS

[5] Bottenberg, Robert A. and Ward, Joe E. Applied Multiple Linear Regression. AD 413 128. Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia: 1963.

The same method is discussed in: Kelly, F.J., Beggs, D.L., and McNeil, K.A. Multiple Regression Approach; Research Design in the Behavioral Sciences. Carbondale: Southern Illinois University Press, 1969.

examination was predicted from knowledge of the student's group membership. The five variables used to predict the examination scores for the 747 students were:

Variable	Description
1	A binary variable reflecting the student's having experienced the Green BSCS version
2	A binary variable reflecting the student's having experienced the Blue BSCS version
3	A binary variable reflecting the student's having experienced the Yellow BSCS version
4	A binary variable reflecting the student's having experienced "other" biology course work
5	A binary variable reflecting the student's having had "no" biology course work

When the five variables listed above were used to predict examination score, the resulting multiple correlation coefficient was .22. That is, only about 5% of the variability in the examination scores could be attributed to the information contained in the five predictor variables (i.e. knowledge of group membership). Given five MSU students entering their second Natural Science course: three who had taken different BSCS courses in high school; another who had a non-BSCS biology course in high school; and a fifth who had no biology in high school, we would predict their scores on the BSCS Comprehensive Final Examination as follows:

Group Student Is In	Predicted Score on BSCS Comprehensive Final Examination
I BSCS Green	24
II BSCS Blue	26
III BSCS Yellow	25
IV Other Biology	24
V No Biology	21

On the other hand, an analysis of variance test among the five groups produced an F value of 9.69 which is significant beyond the .01 level of significance with 4 and 742 degrees of freedom. See Table IV.

TABLE IV

Analysis of Variance for Five High School Biology Experience Groups

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Between Groups	961.3	4	240.3	9.69
Error	18408.5	742	24.8	
Total	19369.8	746		

Conclusion

Whether the rather small predicted differences or the statistically significant variance test has more meaning for science educators is a judgmental matter. The authors venture to suggest

that score prediction via multiple correlation may be more meaningful than the variance test which depends on the size of the sample or population as well as score differences for its significance.

Regardless of one's position on the statistical approach another question is bound to arise. Why didn't the various high school biology experiences--including no biology course experience at all--produce greater differences in mean scores on the BSCS Comprehensive Examination? Does the answer lie in the examination or in the effectiveness of the high school biology courses?

Synopsis

Five groups of college students, each of which had undergone a different high school biology experience, were tested with the BSCS Comprehensive Final Examination to obtain data on the lasting effects of the BSCS biology courses. The analysis of variance approach indicated highly significant differences among the five groups. However, examination of the five means shows that the differences are not great enough to have clear educational meaning. The predicted scores raise questions about the effectiveness of either the BSCS courses, the BSCS examination, or both.